EXECUTIVE SUMMARY

This report presents the results of the Cleanup Alternatives Study/Corrective Measures Study (CAS/CMS) conducted for Quadrant I of the Portsmouth Gaseous Diffusion Plant (PORTS) located near Piketon, Ohio. PORTS currently enriches uranium for electrical power generation and until 1991 provided highly enriched uranium to the United States Navy. The U.S. government began production of enriched uranium at PORTS in the mid-1950s. The production facilities are owned by the U.S. Department of Energy (DOE) and have been leased to the United States Enrichment Corporation since July 1, 1993. Portions of the site are leased to the Ohio Army National Guard. The leased land use is industrial and will remain industrial for some time in the future. Industrial land use includes 1,000 acres of the federal reservation. Portions of PORTS outside of Perimeter Road may be developed for commercial or recreational use in the future.

The environmental restoration program at PORTS is the subject of two enforcement actions. The State of Ohio issued a Consent Decree August 31, 1989 in accordance with Resource Conservation and Recovery Act (RCRA) and its implementing regulations; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980; the National Contingency Plan (NCP); and applicable U.S. Environmental Protection Agency (U.S. EPA) policy. The U.S. EPA Region V issued an Administrative Order by Consent (AOC) September 27, 1989 (amended May 11, 1994 and August 11, 1997) under the authority of Section 3008(h) of the RCRA of 1976. The Ohio Consent Decree requires a CAS and the U.S. EPA Administrative Order by Consent requires a CMS. The Ohio Environmental Protection Agency (Ohio EPA) and U.S. EPA have agreed to a single document, a CAS/CMS report, to fulfill the requirements for these essentially equivalent deliverables. A second amendment to the AOC executed August 11, 1997, relinquished day-to-day oversight of response action activities at PORTS to the Ohio EPA.

Because long-term surveillance, maintenance, and institutional controls will continue indefinitely, future uses of the site are limited and continuation of industrial activity is assumed. Continued industrial use of the PORTS facility is important for the Southern Ohio economy. Stakeholder discussions to date have resulted in the identification of preferred options to maintain industrial land use within Perimeter Road and mixed industrial/commercial and potentially recreational land use within those areas of the federal reservation outside Perimeter Road. Stakeholders have not recommended future residential land use development for PORTS.

The environmental restoration program included the formation of a Decision Team consisting of Ohio EPA, U.S. EPA, and DOE representatives to expedite decisions regarding technical and regulatory issues. Sitewide remediation strategies are influenced by Decision Team actions and supporting policy documents.

DOE evaluated the as low as reasonably achievable (ALARA) principles, considered current and future projected land use, reviewed best available technologies, and examined cleanup levels that have been established at other sites. Consideration of future land use and the ALARA process should be a pivotal part of the final selection of appropriate remedial alternatives for PORTS solid waste management units (SWMUs).

The PORTS Decision Team developed a system to categorize each SWMU on the basis of current and realistic future risk (excluding the future on-site resident exposure scenario) as determined by analyzing data from the RCRA Facility Investigation (RFI) Baseline Risk Assessment. Because both soil and groundwater in portions of Quadrant I are contaminated at levels exceeding acceptable risk, remedial action alternatives must be developed for the following SWMUs:

- X-231A and X-231B Oil Biodegradation Plots,
- 5-Unit Groundwater Investigative Area, and
- X-749/X-120 area groundwater.

The X-231B Southwest Oil Biodegradation Plot was partially closed under RCRA, but residual soil contamination remained. A Director's Final Findings and Orders (DFF&Os), integrating this unit into the CAS/CMS process, was journalized in March 1999.

The PORTS Quadrant I CAS/CMS process leads to the development of remedial alternatives. Evaluation and selection of appropriate remedial alternatives require establishment of remedial action objectives (RAOs). These RAOs are qualitative statements, not numerical cleanup targets, that provide the basis for both generating and evaluating remedial alternatives. Preliminary remediation goals (PRGs) were developed to assess the effectiveness of remedial actions used to meet RAOs. The PRGs were developed by using background values, regulatory criteria, and risk data.

A presumptive response strategy, developed by the U.S. EPA, defines response actions and remedies for sites with contaminated groundwater and presumptive technologies for ex situ treatment of contaminated groundwater. The contaminants and site conditions at PORTS are appropriate for the application of presumptive remedies suggested by the U.S. EPA. As recommended in the presumptive strategy guidance, this CAS/CMS streamlines the technology identification and screening steps and focuses on the evaluation of the presumptive remedy technologies.

Innovative treatment technologies for use in remediation of soil and groundwater, and containment of groundwater plumes also have been evaluated at PORTS and have been incorporated into remedial alternatives when their effectiveness has been demonstrated. New and innovative technologies will continue to be evaluated as appropriate applications are identified.

X-231A AND X-231B OIL BIODEGRADATION PLOTS

Remedial activities are planned for both the X-231A and X-231B Oil Biodegradation Plots because both are potential sources of continuing groundwater contamination. Both units were used for the disposal of waste contaminated with volatile organic compounds (VOCs) and low levels of uranium and technetium. Data resulting from investigation of the units indicated that trichloroethene (TCE) and technetium exceed leaching levels established by Ohio EPA, and uranium is present above its background concentration. TCE was found at various depths in the oil plots, but uranium and technetium are generally confined to depths of less than six feet.

The X-231A covers approximately 54,000 ft^2 and was used for the disposal of a variety of waste containing VOCs during the 1970s. The X-231B Oil Biodegradation Plot covers approximately 37,000 ft^2 and was used for the disposal of hazardous waste during the late 1970s through the early 1980s. Source removal actions at X-231B in 1994 associated with RCRA closure of the unit removed a significant portion of the VOC contamination, but TCE remains at concentrations exceeding its soil leaching level.

A range of potentially viable remedial alternatives has been assembled for soils at X-231A and X-231B. Alternatives have been evaluated for effectiveness, implementability, and cost. All alternatives were selected for their abilities to meet RAOs, address all environmental problems, reduce overall risk, and protect human health and the environment. The remedial alternatives for soils at the X-231A and X-231B Oil Biodegradation Plots include the following:

- Alternative 1 - Institutional Controls

  This alternative includes access and use restrictions, maintenance, and monitoring activities. Under the institutional controls alternative, the contaminant toxicity, mobility, and total volume would be reduced through natural attenuation (e.g., sorption).

- Alternative 2 - Synthetic Covers

This alternative combines the institutional controls and monitoring of Alternative 1 with synthetic covers on the X-231A and X-231B Oil Biodegradation Plots.

C Alternative 3 - VER Wells and Synthetic Covers

This alternative combines all aspects of Alternative 2 with soil remediation using VER wells (nine at the X-231A and ten at X-231B) in conjunction with vapor collection systems.

• Alternative 4 - Multimedia Caps

This alternative combines institutional controls with multimedia capping of the X-231A and X-231B Oil Biodegradation Plots. The multimedia caps would consist of a 80 mil textured High Density Polyethylene (HDPE) geomembrane over an engineered fill base, a drainage layer, a 24 inch thick soil layer, and a 6 inch vegetative soil layer. Should this alternative be selected, implementation will occur without relocation or grouting the underground utilities. However, if a failure to the underground utilities were to occur, activities would be implemented including: immediate repair of the affected utility, an evaluation to relocate the affected underground utility based on impacts to USEC operations, and repair of the capping system. The above contingencies will be incorporated in the Quadrant I O&M Plan. An estimate as a separate line item was included for Alternative 4 which contains the cost of relocating underground utilities in the X-231B Area. This alternative can be effectively implemented with or without relocation of the utilities.

Alternatives 2, 3 and 4 are predicted to meet all RAOs for the X-231A and X-231B. Alternatives 2, 3 and 4 minimize long-term risks to human health and environmental receptors. Alternative 4 also meets the substantive requirements of RCRA for the X-231B Oil Biodegradation Plot. These alternatives are readily implementable and have been proven to be reliable and effective. Table ES.1 summarizes the relative effectiveness and costs for the four remediation alternatives.

Table ES.1. Summary of Alternative Analyses for X-231A and X-231B Soils, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Alternative	Technical Analysis	Human Health Analysis	Environmental Analysis	Institutional Analysis	Capital Cost Analysis (Present Worth, $1000s)	O&M Cost (Present Worth, $1000s)
1 - Institutional Controls	Readily implementable. Deed restrictions and existing fencing would be reliable if site controls are maintained.	No short-term risk. Long-term exposure to onsite workers.	No risk to environmental indicators.	Does not meet all RAOs.	No cost	155
2 - Synthetic Covers	Readily implementable. Caps are an effective and proven technology for preventing infiltration of water.	Short-term risk to remediation workers. Long-term risk to onsite workers is eliminated through elimination of the pathway.	No risk to environmental indicators. Could initially disrupt ecological receptors but is not expected to result in permanent effects.	Meets all Soil RAOs. Does not meet hazardous waste requirements.	1,019	918
3 - VER Wells and Synthetic Covers	Readily implementable. VER wells are an effective and proven technology for removing VOC contamination from soil.	Short-term risk to remediation workers. Long-term risk to onsite workers is decreased through remediation of VOCs.	No risk to environmental indicators. Could initially disrupt ecological receptors but is not expected to result in permanent effects.	Meets all Soil RAOs. Does not meet hazardous waste requirements.	2,633	4,192
4 - Multimedia Caps	Readily implementable. Caps are an effective and proven technology for preventing infiltration of water.	Short-term risk to remediation workers. Long-term risk to onsite workers is eliminated through elimination of the pathway.	No risk to environmental indicators. Could initially disrupt ecological receptors but is not expected to result in permanent effects.	The substantive requirements of RCRA will be met when a multimedia cap is installed at X-231B. Meets all Soil RAOs.	3,244	956

5-UNIT GROUNDWATER INVESTIGATIVE AREA

The 5-Unit Groundwater Investigative Area contains a contaminant plume, consisting primarily of TCE, that encompasses an area extending south from the X-710 Technical Services Building to the X-230K South Holding Pond and east from the southwest corner of the X-326 Process Building Facility to the X-749A Classified Materials Burial Ground. The continuing sources of groundwater contamination in this area, soils in the X-231A and X-231B Oil Biodegradation Plots, have been discussed in the previous section.

A range of potentially viable remedial alternatives has been assembled for groundwater in the 5-Unit Groundwater Investigative Area. All alternatives, except the no action and no further action alternatives, were selected for their abilities to meet RAOs, address all environmental problems, reduce overall risk, and protect human health and the environment. The remedial alternatives for groundwater in the 5-Unit Groundwater Investigative Area include the following:

- Alternative 1 - No Action

  No actions are assumed for this alternative. No access and use restrictions or maintenance or monitoring are included.

- Alternative 2 - No Further Action

  This alternative includes institutional controls, continued operation of the existing 3-well extraction system, and groundwater monitoring. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

- Alternative 3 - Groundwater Extraction

  This alternative includes institutional controls, a conventional 14-well groundwater extraction system, and groundwater monitoring. Institutional controls include access and use restrictions, maintenance, and monitoring.

- Alternative 4 - Oxidant Injection and Groundwater Extraction

  This alternative includes institutional controls, a conventional 14-well groundwater extraction system, initial contaminant reduction using oxidant injection, and groundwater monitoring. Initial contaminant reduction using oxidants in conjunction with groundwater extraction/reinjection will eliminate large areas of contamination in the first year of operation and will minimize the amount of extracted groundwater requiring treatment at on site facilities. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

- Alternative 5 - VER Wells at X-231A and X-231B, and Groundwater Extraction

  This alternative consists of institutional controls, 19 VER wells installed in the X-231A and X-231B Biodegradation Plots, and a conventional 9-well groundwater extraction system. VER wells will be used to dewater the Gallia water-bearing zone and remove vadose zone contaminants beneath the X-231A and X-231B Oil Biodegradation Plots. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

- Alternative 6 - VER Wells at X-231A and X-231B, Oxidant Injection, and Groundwater Extraction

  This alternative consists of institutional controls, oxidant injection, and a conventional 9-well groundwater extraction system. VER wells will dewater the Gallia aquifer beneath the X-231A and X-231B and remove vadose zone contaminants. Initial contaminant reduction using oxidants in conjunction with groundwater extraction/reinjection will eliminate large areas of contamination in the first year of operation and will minimize the amount of extracted groundwater requiring treatment at onsite facilities. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

Table ES.2 summarizes the relative effectiveness and costs for the six 5-Unit Groundwater Investigative Area alternatives evaluated.

Table ES.2. Summary of Alternative Analyses for the 5-Unit Groundwater Investigative Area, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Alternative	Technical Analysis	Human Health Analysis	Environmental Analysis	Institutional Analysis	Estimated Maximum TCE Concentration at 30 years (µg/L)	Estimated Maximum ELCR at 30 years	Estimated Remaining Plume Area Above PRGs (ft^2)	30 Year Present Worth Costs ($1,000s) Capital/ O&M
1 - No Action	No implementation is required.	No short-term risk. Long-term exposure to on-site workers.	No risk to environmental indicators.	Does not meet RAOs.	258	5.0×10^{-5}	2,601,500	0/0
2 - No Further Action	Readily implementable. Deed and land use restrictions would be reliable if site controls are maintained. Three well groundwater extraction system and treatment facility currently operating.	No short-term risk.	Risk to environmental receptors if contaminated groundwater infiltrates to surface water.	Meets RAOs for on-site personnel and recreational visitors.	167	3.2×10^{-5}	1,687,400	0/4,983
3 - Groundwater Extraction	Readily implementable. Institutional controls will be retained.	Short-term risk to remediation workers.	Short-term risk to environmental indicators is minimal. No long-term risk to environmental receptors.	Meets all RAOs.	<5	$< 1.0 \times 10^{-6}$	0	1,056/6,429
4 - Oxidant Injection and Groundwater Extraction	Extraction wells and upgrades to treatment facility readily implementable. Oxidant injection less reliable. Institutional controls will be retained.	Short-term risk to remediation workers.	Short-term risk to ecological receptors is minimal. No long-term risk to environmental receptors.	Meets all RAOs.	<5	$< 1.0 \times 10^{-6}$	0	2,674/14,176*
5 - VER Wells at X-231A and X-231B and Groundwater Extraction	Extraction wells and upgrades to treatment facility readily implementable. Oxidant injection less reliable. Institutional controls will be retained.	Short-term risk to remediation workers.	Short-term risk to ecological receptors is minimal. No long-term risk to environmental receptors.	Meets all RAOs.	<5	$< 1.0 \times 10^{-6}$	0	2,212/17,404
6 - VER Wells at X-231A and X-231B, Oxidant Injection, and Groundwater Extraction	VER wells, conventional extraction wells, and upgrades to treatment facility readily implementable.	Short-term risk to remediation workers.	Short-term risk to ecological receptors is minimal. No long-term risk to environmental receptors.	Meets all RAOs except achieving PRGs in Groundwater.	8	1.5×10^{-6}	11,444	3,989/27,529*

RAOs = Remedial Action Objectives

* This alternative involves a significant first year cost of greater than $7 million.

Alternatives 3 through 5 meet all RAOs and will significantly reduce the overall mass of contaminants in the groundwater. Alternative 6 meets all RAOs except for meeting PRGs in groundwater. Alternatives 3 through 6 minimize long-term risks to human health and environmental receptors. These alternatives are readily implementable and have been proven to be reliable and effective. More aggressive extraction or remediation alternatives are prohibited by operational industrial activities and infrastructure and by the hydrogeologic conditions at the 5-Unit Groundwater Investigative Area.

X-749/X-120 AREA

The X-749/X-120 Area contains a contaminant plume, consisting primarily of TCE, that encompasses an area extending south from Hewes Street to immediately north of the reservation boundary where it is contained by a barrier that extends to bedrock. The plume also extends east from the unnamed Southwest Drainage Ditch to the PK Landfill area. Two sources of groundwater contamination formerly existed, the X-749 landfill and the site of the defunct X-120 Goodyear Training Facility. Soil samples taken from the X-120 area during the RFI show that contaminants are no longer present above leaching levels established by the Ohio EPA, indicating it is no longer a source of groundwater contamination. The measures taken at the X-749 landfill in 1993 (isolation of the unit using a multimedia cap, barrier walls and groundwater collection trenches) effectively removed it as source of ongoing contamination.

DOE has spent more than $20 million on the following projects in this area:

- X-120 Horizontal Well
- X-625 Treatment Facility
- X-749 IRM Barrier Wall
- Peter Kiewit landfill cap
- Peter Kiewit groundwater collection system
- X-749 landfill cap
- X-749 barrier walls and groundwater collection system

In addition, DOE has conducted pilot projects across the site at a cost of more than $4 million to affect cleanup while determining the viability of several technologies, including oxidant injection, steam stripping, and vacuum enhanced recovery.

A comprehensive series of model simulations incorporating various remedial technologies, both alone and in combination, have been evaluated. These model simulations indicate that it is not practicable to move

a sufficient quantity of water through the Gallia saturated zone to remediate groundwater and associated saturated soils to concentrations less than PRGs in all areas of the X-749/X-120 plume within the targeted 30-year time frame. Even with extensive application of best available technologies, the hydrogeologic conditions in this area preclude achieving the target risk level of 1×10^{-6} within 30 years. However, these simulations do indicate that groundwater contaminant levels can be reduced to acceptable risk levels in a much shorter time frame, in effect attaining the concentrations which are as low as reasonably achievable given the constraints of the local hydrogeologic system.

A range of potentially viable remedial alternatives has been assembled for groundwater in the X-749/X-120 Area. All alternatives, except the no action and no further action alternatives, were selected for their abilities to meet RAOs, address all environmental problems, reduce overall risk, and protect human health and the environment. The remedial alternatives for groundwater in the X-749/X-120 Area include the following:

- Alternative 1 - No Action

  No actions are assumed for this alternative. No access and use restrictions or maintenance and monitoring are included.

- Alternative 2 - No Further Action

  This alternative includes institutional controls and groundwater monitoring. Institutional controls include access and use restrictions, maintenance, and monitoring. This alternative includes continued operation of the existing X-120 horizontal well, the X-749 southwest and east trenches, and the Peter Kiewit collection trench.

- Alternative 3 - Pump and Treat

  This alternative includes conventional groundwater extraction with treatment at onsite facilities. The existing X-120 horizontal well, the Peter Kiewit trench and the southwest X-749 trench continue operation. A barrier wall is installed at the south end of X-749 and where the existing east X-749 collection trench is located, effectively containing contamination within this landfill. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

- Alternative 4 - Pump and Treat with Subsequent Phytoremediation

This alternative includes conventional groundwater extraction for 20 years with treatment of extracted groundwater at onsite facilities. A barrier wall is installed at the south end of X-749 and where the existing east X-749 collection trench is located, effectively containing contamination within this landfill. The existing X-120 horizontal well, the Peter Kiewit trench and the southwest X-749 trench continue operation. Implementation of phytoremediation begins in the 21st year. With implementation of phytoremediation, all active remedial measures, except the southwest X-749 and the Peter Kiewit collection trenches, are removed from operation. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

C Alternative 5 - Phytoremediation

Approximately 27.5 acres of hybrid poplars are planted in this alternative. A barrier wall is installed at the south end of X-749 and where the existing east X-749 collection trench is located, effectively containing contamination within this landfill. The southwest X-749 and the Peter Kiewit collection trenches continue operation. Institutional controls include access and use restrictions, maintenance, and monitoring activities.

- Alternative 6 - Enhanced Bioremediation and Phytoremediation

This alternative includes bioremediation and phytoremediation, operation of selected existing trenches, and installation of containment walls. Enhanced bioremediation is considered in an area of 5.9 acres coinciding with the current Gallia TCE distribution exceeding 100 Fg/L near the X-120 horizontal well. Enhanced bioremediation and phytoremediation is considered in an area of 8.3 acres covering the current Gallia TCE distribution exceeding 1,000 Fg/L west of the X-749 landfill. Phytoremediation is considered in two areas (11.9 acres and 1.7 acres) that are located south and east of the X-749 landfill, respectively. Enhanced bioremediation is performed from 0 to 2 years, phytoremediation is considered effective beginning the 3rd year. The X-120 horizontal well is operated from 0 to 2 years. A barrier wall is installed at the south end of the X-749 landfill and where the existing east X-749 trench is located. Monitoring and deed restrictions are also implemented in this alternative.

Table ES.3 summarizes the relative effectiveness and costs for the six X-749/X-120 Area alternatives evaluated.

Alternatives 3 through 6 meet all RAOs and will significantly reduce the overall mass of contaminants in the groundwater. Alternatives 3 through 6 minimize long-term risks to human health and environmental receptors. However, Alternative 6 is the only alternative that minimizes the impact on areas slated for reindustrialization. The area west of the X-749 landfill and south of Lewis Street extending to the Perimeter Road has been identified as the location of a new UF_6 Tails Conversion Facility, scheduled to be in operation within four years. In addition, construction of a new uranium enrichment facility may take place in this area if PORTS is selected by USEC for this new plant. Reindustrialization may affect the installation and/or placement of above ground items (e.g., trees, extraction wells, etc.) associated with remedial technologies in this area. However, the re-industrialization prospects for the X-749/X-120 area have no impact on the model or the present selection of remedial alternatives. The impacts that re-industrialization efforts may have on the selected alternative in this area will be evaluated when decisions regarding D&D have been finalized, and/or when the scheduled five year reviews are conducted to ensure compatibility with development of new land use decisions and performance standards. At that time, other remedial alternatives can be evaluated if warranted.

Table ES.3. Summary of Alternative Analyses for the X-749/X-120 Area, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Alternative	Technical Analysis	Human Health Analysis	Environmental Analysis	Institutional Analysis	Contaminant Plume Summary After 30 years		30 Year Present Worth Costs ($1,000s) Capital/O&M
					Maximum Remaining Concentrations (µg/L)	Remaining Area Above PRG (Million ft^2)	
1 - No Action	No implementation is required.	No short-term risk. Long-term exposure to onsite workers.	No risk to environmental indicators.	Does not meet RAOs.	2,790	5.72	0/0
2 - No Further Action	Readily implementable. Deed and land use restrictions would be reliable if site controls are maintained.	No short-term risk.	No risk to environmental indicators.	Does not meet RAOs.	1,340	4.06	0/5,974
3 - Pump and Treat	Readily implementable. Installation of wells will be required.	Short-term risk to remediation workers.	Short-term effect on ecological receptors is minimal.	Meets all RAOs.	43	0.250	2,564/12,749
4 - Pump and Treat with Subsequent Phytoremediation	Readily implementable. Installation of wells and trees will be required.	Short-term risk to remediation workers.	Short-term effect on ecological receptors is minimal.	Meets all RAOs.	16	0.638	2,564/11,623
5 - Phytoremediation	Readily implementable. Installation of trees will be required.	Short-term risk to remediation workers.	Short-term effect on ecological receptors is minimal.	Meets all RAOs.	46	0.273	602/5,433
6 - Enhanced Bioremediation and Phyto-remediation	Readily implementable. Installation of trees will be required.	Short-term risk to remediation workers.	Short-term effect on ecological receptors is minimal.	Meets all RAOs.	91	1.19	5,228/10,182

RAOs = Remedial Action Objectives